

3.1 EARTH

This section provides information about soil and geology related to the Plymouth Generating Facility (PGF) site area, proposed plant site (including the water supply/wastewater pipeline and gas pipeline), transmission interconnection, access road, and the alternate transmission interconnections and access alternative. Existing geologic and soil conditions and potential environmental impacts attributable to construction and operation of the PGF are described. Potential geologic and seismic hazards that would affect the PGF are also discussed.

3.1.1 AFFECTED ENVIRONMENT

Existing site geology and soil information was obtained from published data and by performing a site reconnaissance of the plant site and infrastructure corridors. References consulted include:

- Soil Survey of Benton County (USDA 1971) for surficial soil types and distributions
- State of Washington Department of Natural Resources (WDNR) geologic maps and reports
- Reports and studies regarding potential seismic and volcanic hazards in the site region
- Washington State Department of Ecology (Ecology) water well reports

A site reconnaissance of the site area and vicinity was conducted on March 7, 2002 by a professional geologist. The reconnaissance consisted of traversing the plant site, traveling the transmission interconnections and access road routes, observing soil and rock exposures, sampling the subsurface soils with a hand auger, and documenting observations with written notes and photographs.

3.1.1.1 Regional and Site Area

3.1.1.1.1 Topography

The site area is located on the Columbia River Plateau (Plateau). The Plateau is an expansive topographic upland situated east of the Cascade Mountains that has been incised by the Columbia River and its tributaries. The irregular outline of the Plateau was produced by successive flows of basalt lava (flood basalt) that spread for hundreds of miles to give the Plateau its broad level topography, with post-basalt ridges and buttes (conspicuously isolated hills or small mountains) in its southern portion. The site area is characterized by relatively flat to moderately rolling terrain with occasional buttes and small rock outcrops. Elevations range from 250 to 750 feet above mean sea level. The Columbia River is the main drainage in the area and is fed by several small drainages, such as Fourmile Canyon located east of the plant site.

3.1.1.1.2 Regional Geologic Setting

Based on the predominant geologic structural fabric, the Columbia River Plateau has been subdivided into three informal geologic structural subprovinces: Palouse Slope, Blue Mountains, and the Yakima Fold Belt. The site area is within the Yakima Fold Belt of the Plateau, an area characterized by narrow, asymmetrical anticlines (folds that form the higher topographic features) spaced between 3 and 30 miles apart. The Columbia River Basalt Group is the youngest and most studied flood basalt of the Columbia River Plateau. Although commonly referred to as a plateau, the basalt has been faulted, sharply folded and broadly warped, so that its top varies in elevation from slightly below sea level in the Pasco Basin to more than 1.5 miles above sea level in the Wallowa Mountains of northeast Oregon. The fault and fold structures in the site area that exhibit displacement during the Quaternary period (last 2 million years before present) are shown on Figure 3.1-1.

Alluvial deposits consisting primarily of sand and gravel mantle the basalt bedrock throughout the region. From approximately 13,500 to 15,000 years ago, glacial advance and retreat created ice dams in northern Idaho. These dams formed ancient Lake Missoula, a glacial lake that covered a significant portion of what is now western Montana. These ice dams eventually failed due to the rising water levels and released catastrophic floods that swept across southeastern Washington and along the Columbia River to the Pacific Ocean. As ancient Lake Missoula drained (in an estimated 24 to 48 hours per event), the site area was repeatedly inundated with flood waters. The Missoula Floods pooled in the Pasco Basin, then drained down the Columbia River primarily through Wallula Gap, spreading out within the Umatilla Basin. The force of water completely stripped existing overburden soils and scoured the surface of the Columbia River Basalt, forming scabland topography. Frequent flooding deposited layers of unconsolidated to poorly consolidated, crudely stratified sand and gravel alluvium, with occasional boulders and silt lenses, on the basalt bedrock within the site area.

Since the cessation of the floods, natural erosional and depositional processes have modified the topography, resulting in additional deposits of loess (wind blown deposits), silts, sands, and gravels of fluvial and alluvial origin throughout the site area.

3.1.1.1.3 Local Soils and Geology

Surficial Geology

Extensive areas of glaciofluvial (deposits from glacier meltwater) and reworked flood gravel terraces occur around the site area with eolian (sediments transported by wind) sand and silt mantling most of the gravel terraces. Recent alluvial (sediments left by a stream on the stream's channel or floodplain) gravels occur on both banks of the Columbia River downstream of McNary Dam.

The geologic map of the east half of the Hermiston quadrangle, Washington (WDNR 1994) (Figure 3.1-2), shows that the site area is underlain by glacial outburst flood deposits comprised mainly of gravel [Qfg] with overlying loess [Ql] deposits located at higher elevations in the surrounding area. Water well records (Ecology 2002) indicate that south of the plant site along Christy Road, alluvial deposits range from 30 to 70 feet thick and consist of a 10-foot sand layer overlying gravel deposits.

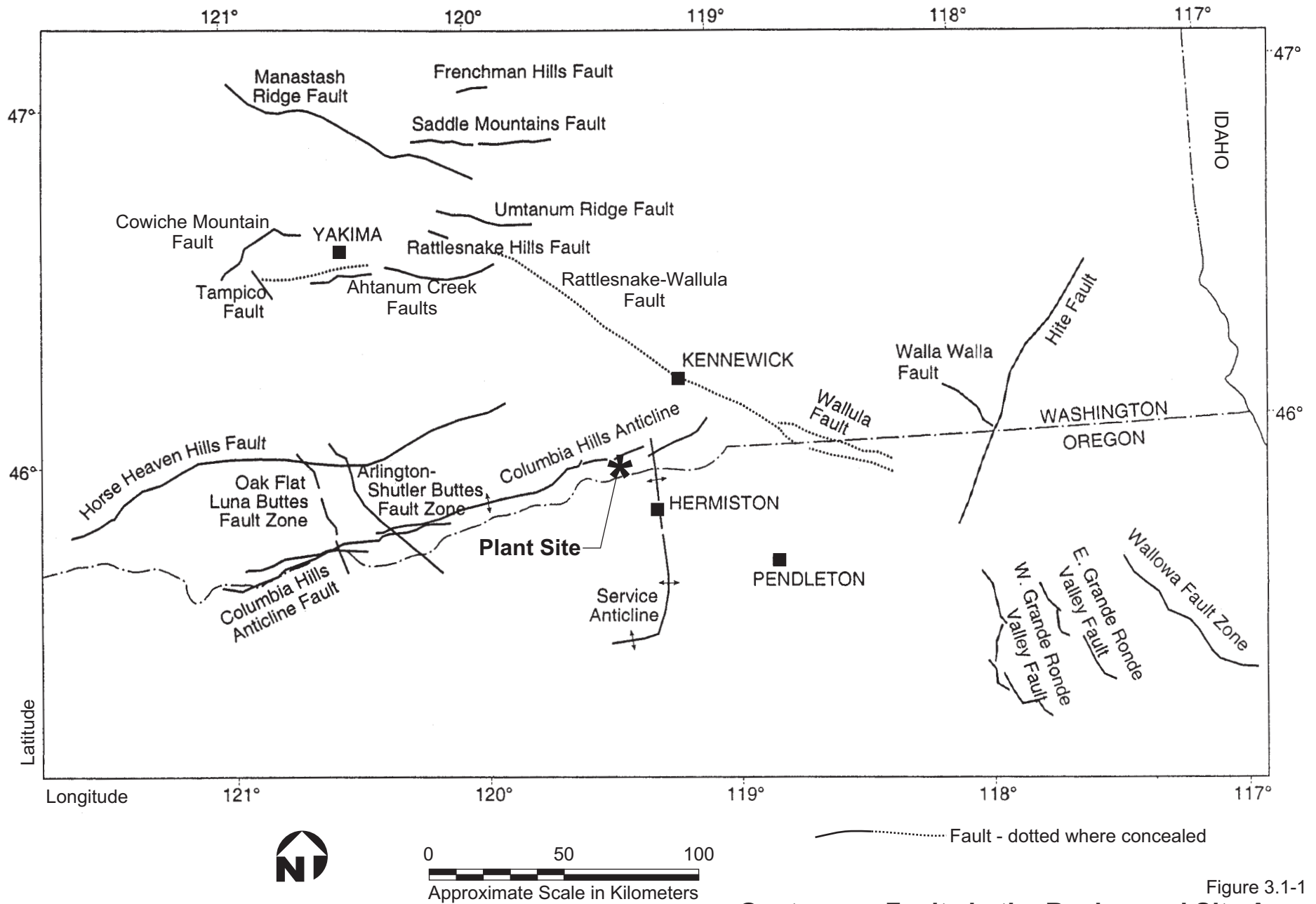
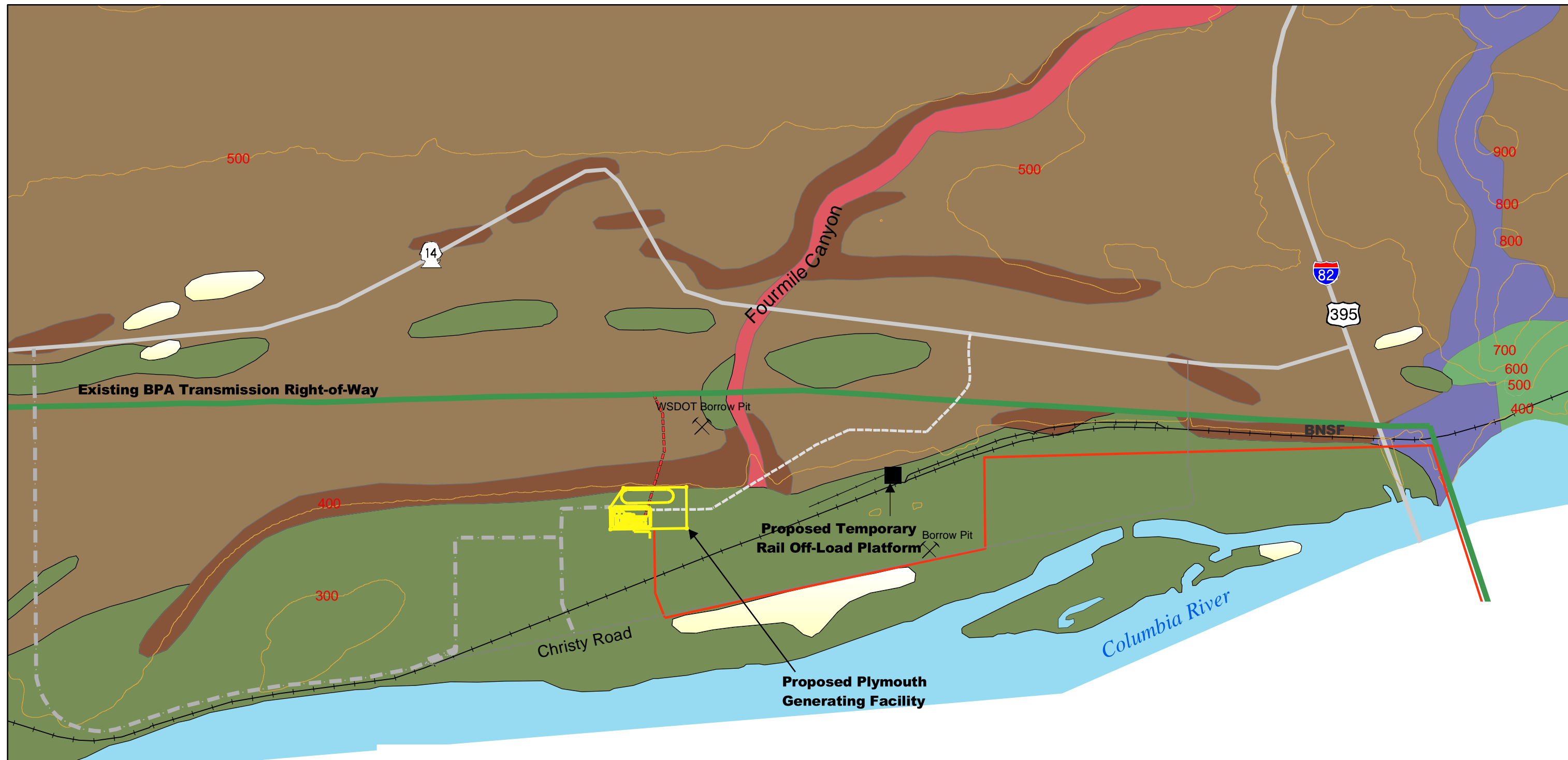


Figure 3.1-1
Quaternary Faults in the Region and Site Area

Figure 3.1-1 (Continued)



Legend

✕ Borrow Pit

■ Proposed Temporary Rail Off-Load Platform

— Proposed Plymouth Generating Facility

— BPA Transmission Right-of-Way

--- Proposed and Alternate 230 kV Transmission Interconnection

— Alternate Benton PUD/BPA Transmission Interconnection

--- Alternate Access Road

--- Proposed Access Road

— BNSF Railway/Rail Siding

100 100 ft contours

Mv(sem) Elephant Mountain Member Wanapum Basalts

Mv(sp) Pomona Member

Qa Alluvium

Qd Dune Sands

Qfg Outburst flood Deposits, gravel

Ql Loess



URS

Source: Washington Dept. Natural Resources
and USGS, Hermiston 1:100,000 quad
Stateplane Nad 83

Figure 3.1-2
Site Area Geology

Plymouth Generating Facility
Plymouth, Washington

Figure 3.1-2 (Continued)

Near-surface soils are described in the soil survey of Benton County Area, Washington (USDA 1971) and have been classified and mapped as shown on Figure 3.1-3. The soils are situated within the Hezel-Quincy-Burbank general soil association unit, which extends approximately 5 miles north of the Columbia River. These gently sloping soils have a loamy sand surface layer that is very deep to shallow over gravel, lacustrine material (lake sediments), or basalt rock. Generally speaking, these soils have been formed in loess, lacustrine, or alluvial environments. These descriptions typically apply to natural, surficial soils in the upper few feet of the soil profile.

According to the Mineral Resources Map (WDNR 1978), no known locations of resources, such as sands and gravel deposits, are located within the site area. In addition, there are no known petroleum resources in the site area.

Bedrock Geology

Basalt volcanic rock underlies the site area. Water well records (Ecology 2002) south of the plant site along Christy Road indicate that the top of the basalt bedrock varies between 30 and 70 feet beneath the ground surface.

3.1.1.1.4 Geologic Hazards

Potential natural hazards associated with geologic conditions include mass wasting, erosion and deposition, surface fault rupture, landslides, subsidence, volcanism, and earthquake-induced ground motion, liquefaction, and ground deformation. Of these natural hazards, only erosion, volcanism, and earthquake-induced ground shaking are considered to be potential hazards at the plant site. These hazards are discussed in general below. Erosion is considered a site-specific hazard and is discussed in more detail in Section 3.1.2, Environmental Consequences.

Seismic Hazards

The site area is located in a seismically active area of the Pacific Northwest. Earthquakes in the Pacific Northwest can originate from four different types of sources:

- Interplate earthquakes on the Cascadia Subduction Zone (CSZ) associated with eastward movement of the Juan de Fuca tectonic plate beneath the North American plate (Figure 3.1-4)
- Intraplate earthquakes within the subducting Juan de Fuca plate as it sinks and breaks up below the North American plate
- Shallow crustal earthquakes on faults within the North American plate west and east of the Cascades
- Volcanic earthquakes such as those associated with the eruption of Mount St. Helens

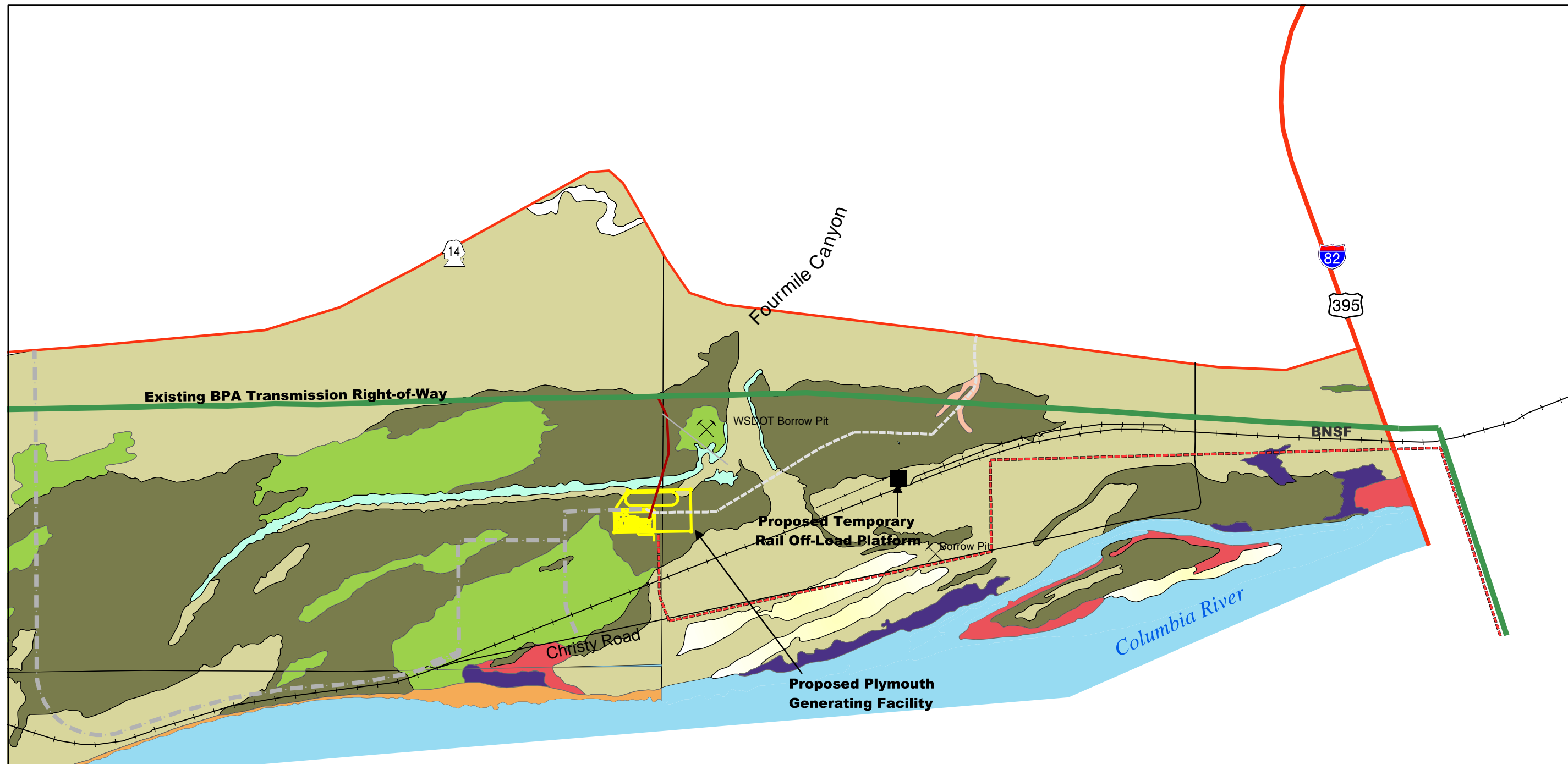
These different sources are shown on Figure 3.1-5.

The CSZ is capable of generating a great earthquake of magnitude 8 (M8) or greater. This type of event apparently occurs every several hundred to 1,000 years and results in major earthquakes at depths of approximately 6 to 25 miles beneath coastal and offshore British Columbia, Washington, Oregon, and northern California. Geologic studies during the last 10 to 15 years indicate that multiple great earthquakes have occurred on the CSZ during the Holocene epoch (last 10,000 to 11,000 years) (e.g., Atwater et al. 1995; Atwater 1996; Atwater and Hemphill-Haley 1997; Nelson et al. 1995). Geologic evidence for the most recent event (approximately 300 years before present [b.p.]) has been found at many coastal locations in Washington, Oregon, and Vancouver Island, B.C. It is uncertain whether a single earthquake or several separate earthquakes closely spaced in time caused the geologic effects at these locations. However, there is a general consensus that the CSZ has generated multiple earthquakes of M8 or larger in the past few thousand years (Atwater et al. 1995; Nelson and Personius 1996; Weaver and Shedlock 1996). Analysis of historical records of tsunamis in Japan and tree ring dating of trees in western Washington and Oregon support the interpretation that the most recent great earthquake on the CSZ may have ruptured most or the entire length of the CSZ about 300 years ago and was about M9 (Satake and Tanioka 1996).

Intraplate seismic events appear to be more widespread geographically and result from rupture within the subducted plate at depths of 20 to 55 miles. Based primarily on the historical seismicity of intraplate origin in western Washington and other subduction zones of the world, the intraplate zone is generally considered capable of generating earthquakes as large as M7.5. This source has generated three of the largest historic seismic events to affect the Pacific Northwest: the 1949 M7.1 Olympia earthquake; the 1965 M6.5 Seattle earthquake (Thorsen 1986), and the 2001 M6.8 Nisqually earthquake. Because intraplate earthquakes do not cause deformation at the ground surface that can be distinguished from other types of earthquakes, the typical frequency of these earthquakes cannot be readily assessed from geologic data. However, these types of earthquakes have historically caused the greatest amount of damage in Washington, and their rates can be estimated from historical seismicity.

In addition to interplate (subduction zone) and intraplate earthquakes on the CSZ, there is increasing geologic evidence that other regional seismic sources have the potential to produce shallow earthquakes of up to M7.5 at shallow depths of up to 10 to 15 miles within the continental crust. These shallow crustal seismic events appear to be more widespread geographically relative to the other sources of historical seismicity, and often occur along mapped or postulated faults exposed at the earth's surface. Based primarily on historic and paleoseismicity, shallow crustal faults with demonstrated displacement during the Holocene epoch are considered capable of generating earthquakes greater than M6 and potentially as large as M7.0 to M7.5, such as the 1872 North Cascade event estimated at M7.3 (Nelson et al. 1988). Faults that exhibit displacement during the late Quaternary (2 million years to present) are generally considered potentially active.

The site area is located east of the Cascade Mountains in an area with a relatively low level of historical seismicity (Figure 3.1-6). Locations of major historic earthquakes in Oregon and Washington are shown on Figure 3.1-7. The largest historic earthquake in the region was the 1936 6.1 Milton-Freewater earthquake located approximately 60 miles east of the site.



Legend

- Proposed Temporary Rail Off-Load Platform
- × Borrow Pit
- BPA Transmission Right-of-Way
- - - Alternate Benton PUD/BPA Transmission Interconnection
- Proposed and Alternate 230 kV Transmission Interconnection
- - - Alternate Access Road
- - - Proposed Access Road
- Proposed Plymouth Generating Facility
- BNSF Railway/Rail Siding

- bbc - Burbank loamy fine sand 0-15% slope
- bde - Burbank loamy fine sand basalt sub 0-30% slope
- bfe - Burbank rocky loamy fine sand basalt sub 0-30% slope
- du - dune land
- fec - Finley fine sandy loam 0-15% slope
- paa - Pasco fine sandy loam 0-2% slope
- pca - Pasco silt loam 0-2% slope
- que - Quincy loamy sand 0-30% slope
- qye - Quincy loamy sand 0-30% slope
- rh - riverwash

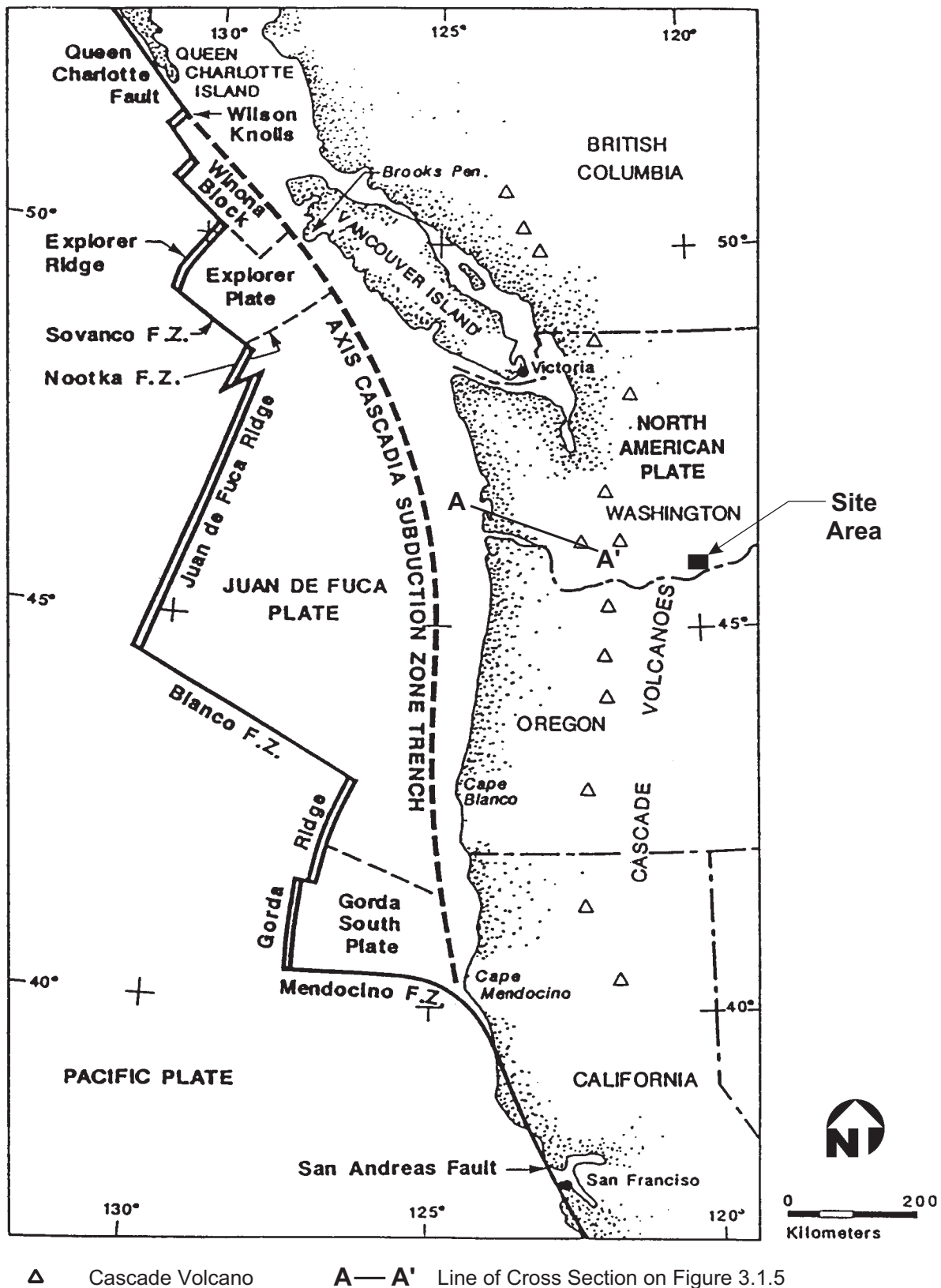


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Source: USDA Soil Conservation Survey
1971 Soil Survey of Benton County Area, WA
Stateplane Nad 83

Figure 3.1-3
Site Area Soils
Plymouth Generating Facility
Plymouth, Washington

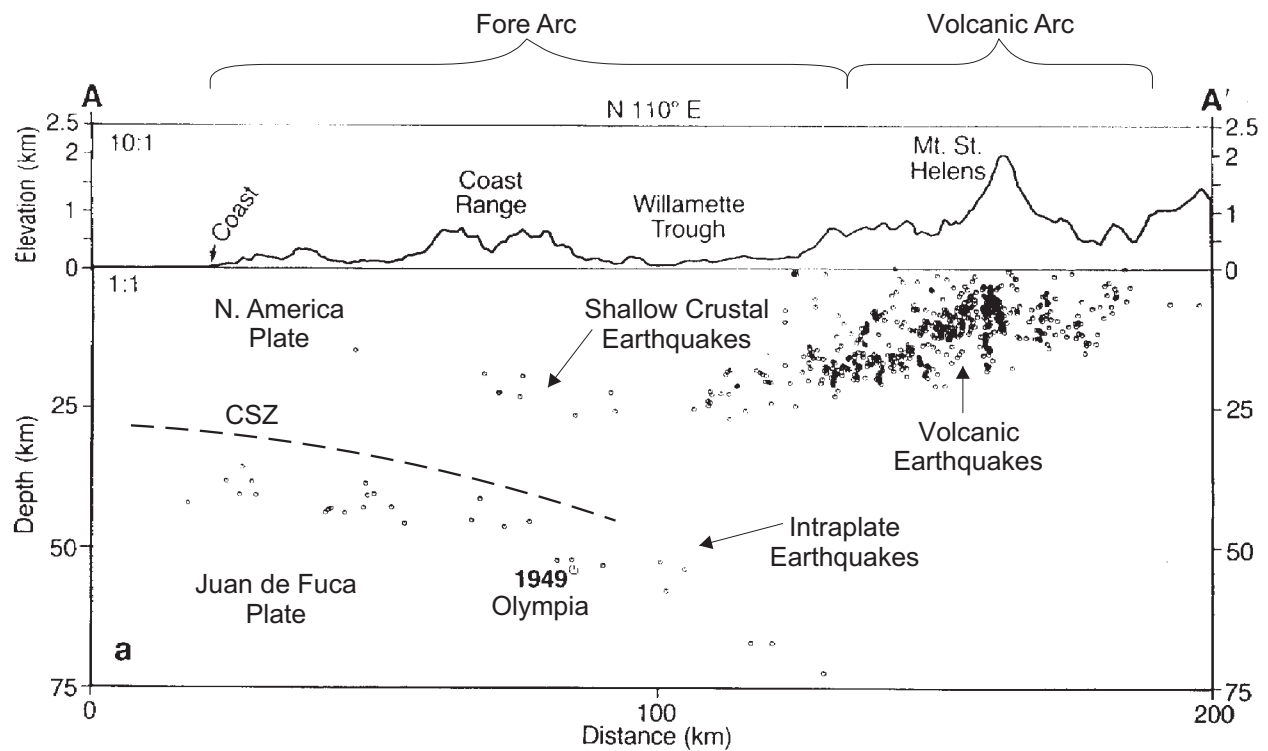
Figure 3.1-3 (Continued)



Modified from Washington Public Power Supply System (1988)
(after Riddihough, 1984).

Figure 3.1-4
**Tectonic Setting of the
Cascadia Subduction Zone**

Figure 3.1-4 (Continued)



Southwestern Washington Cross Section A-A'

CSZ = Cascadian Subduction Zone
See Figure 3.1-4 for cross section location.

Figure 3.1-5
**Cross-Section of
Earthquake Epicenters Beneath
Southwestern Washington**

Figure 3.1-5 (Continued)